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Rock Island Arsenal Laboratory

TECHNICAL REPORT

MULTIMETAL COATING PROCESS FOR COMPOSITE STEEL, MAGNESIUM AND ALUMINUM STRUCTURES
(Interim Report)

By

Jodie Doss

Department of the Army Project No. 1-H-0-24401-A-110-05

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Laboratory Director

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Rock Island Arsenal
Rock Island, Illinois

ABSTRACT

Aluminum, steel and magnesium trimetal assemblies were simultaneously coated in order to decrease galvanic corrosion, and to develop coatings to be used for recoating structurally united components containing dissimilar metals. The composite specimens were processed in modified stannous pyrophosphate solutions. The trimetal assemblies containing various alloys of aluminum were also processed in the stannous pyrophosphate solution. Composite specimens containing a large aluminum panel and a small magnesium panel, or the reverse, were processed in the stannous pyrophosphate solution. Solutions containing other tin compounds were investigated as solutions to coat trimetal assemblies.

RECOMMENDATIONS

The stannate-pyrophosphate solution should be further investigated for use on Army materiel.

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OBJECT

To develop methods of producing corrosion resistant coatings on assemblies of magnesium, aluminum and steel for use in rebuild work.

INTRODUCTION

The following investigation was a continuation of the work related in the report entitled, "Multimetal Coating Process For Composite Steel, Magnesium and Aluminum Structures."[1]

In the report it was stated that the aluminum, steel and magnesium trimetal assemblies were simultaneously coated in order to decrease galvanic corrosion, and to develop coatings to be used for recoating structurally united components containing dissimilar metals. The following experimental solutions were utilized to coat trimetal assemblies: stannate-chromate, phosphate, stannate-gluconate, stannate-hypophosphite and stannous pyrophosphate. The stannous pyrophosphate solution produced the best coatings on the assemblies.

During the current investigation the previously developed stannous pyrophosphate solution was further examined. Other solutions containing tin compounds were also prepared and examined. This is an interim report containing the results of these investigations.

PROCEDURE AND RESULTS

Materials:

The aluminum materials used in the investigation were listed under Federal Specification QQ-A-561, 1100, QQ-A-355, 2024, QQ-A-318,5052, QQ-A-327,6061, QQ-A-283,7075. The magnesium alloy was QQ-M-44,AZ31B. Panels were prepared from sheet material in the following sizes of 2" x 3" or 4" x 6" x .0625" with 1/4" holes drilled through the centers. The two aluminum and magnesium panels were securely fastened together, with the major dimensions at right angle to each other, by means of a 1/4" round head steel machine screw and nut.

Unless another aluminum alloy has been designated, the aluminum alloy used in the trimetal assembly was the 5052 alloy.

The composite specimens were degreased, utilizing a trichloroethylene vapor degreaser, prior to processing.

Stannous Pyrophosphate Solution:

In the previous report(1) a stannous pyrophosphate solution was developed and found to offer the best coating on the trimetal assembly. The composition of the solution was as follows:

50 grams $Sn_2P_2O_7$
50 grams $Na_4P_2O_7.10H_2O$
10 grams dextrine
1 gram gelatin
Enough water to make a one liter solution.

In this effort, the above formulation was operated at 195 ± 5°F. The pH of the prepared solution was approximately 6.2. The pH was further adjusted to between 7 and 9 with a 5N NaoH solution. During the previous investigation it was found that the best coating was obtained between pH 7 and 8.2.

The first phase of the present investigation was to ascertain if there was an optimum pH within the range of 7 and 8.2. The stannous pyrophosphate solution was prepared and the pH of the solution was adjusted to 7 with a 5N NaoH solution. The solution was stepwisely adjusted between 7 and 8.2, at 0.1 intervals, utilizing a 5N NaoH solution. After each 0.1 interval a composite specimen was processed in the solution for twenty minutes. There were no appreciable differences between the specimens processed at the different pH values.

The second phase of the present investigation was to determine if there is an optimum solution concentration. The concentration of the stannous pyrophosphate in a liter solution was stepwisely adjusted between 20 and 50 grams, at ten gram intervals. After each addition, a composite specimen was processed. There was no apparent improvements in the coatings.

The concentration of the sodium pyrophosphate in a liter solution was likewise adjusted, stepwisely between 50 and 125 grams, at 25 gram intervals. After each

addition a composite specimen was processed. There was evidently no improvement.

Composite Specimens Containing Other Aluminum Alloys:

For the preceding experiments, the 5052 alloy was used as part of the trimetal assembly. During the next investigation the 1100, 2024, 6061 and 7075 aluminum alloys were used as the aluminum component of the trimetal assemblies.

The above trimetal assemblies were processed for twenty minutes in a stannous pyrophosphate solution, prepared according to the previous formulation. After processing, the magesium specimens appeared to be covered with dark conversion coatings, and shiny tin coatings were produced on the steel panels.

The 1100 alloy and the 2024 alloy were coated with tin. The 6061 and 7075 alloys either had no coating or were only partially coated.

In order to deposit a satisfactory tin coating, it was necessary to alkaline clean the 6061 and 7075 alloys prior to processing in the stannous pyrophosphate solution. The composition of the cleaner was as follows:

22 grams sodium carbonate
22 grams trisodium phosphate
Enough water to make a one liter solution

The aluminum alloys were immersed in the solution at 190^{o}F. for five minutes.

The trimetal assemblies containing the different aluminum alloys were exposed in a 5% salt fog cabinet for corrosion resistance tests. The salt fog cabinet was operated in accordance with Method 811.1 of Federal Test Method Standard No. 151. After five hours exposure, the composite specimens appeared to have small amounts of galvanic corrosion products present at the junction of the aluminum and magnesium panels and where the steel screw and nut make contact. The tin coating on the 2024 and the 7075 alloy panels appeared to have poor adhesion. Blisters were visible at the intersection of the aluminum and magnesium panels, and the coated 2024 aluminum alloy had small corrosion spots over the surface of the panel.

Varied Area Ratio of Aluminum Specimen to Magnesium Specimen:

Composite specimens were prepared in which the aluminum panel was 4" x 6" and the magnesium was 2" x 3". A similar

trimetal assembly was prepared in which the aluminum panel was 2" x 3" and the magnesium was 4" x 6". The above sizes were prepared containing 1100, 2024, 5052, 6061 and 7075 alloy specimens.

The assembled specimens were processed in the pyrophosphate solution for twenty minutes. The typical shiny coatings were present on the specimens containing the 1100, 2024 and 5052 alloy panels. In order to obtain the coating on the 6061 and 7075 specimens, it was necessary to alkaline clean the aluminum and to raise the pH of the processing solution from approximately 7.3 to 8.2 with a 5N NaoH solution. This pH is also satisfactory for the other aluminum alloys.

<u>Sodium Stannate - Sodium Pyrophosphate Solution</u>:

It was subsequently determined, through further work, that the following solution would satisfactorily coat the trimetal assembly.

40 grams sodium stannate $Na_2SnO_3.3H_2O$

50 grams sodium pyrophosphate $Na_4P_2O_7.10H_2O$

10 grams dextrine

1 gram gelatin

Enough water to make a one liter solution

The above solution was operated at 195 ± 5°F.

The pH of the solution was adjusted to 6.7 with H_3PO_4(85%) solution. A trimetal assembly was immersed in the solution for thirty minutes. There was an apparent bright tin coating on the three metals in the assembly. Another composite specimen was processed for thirty minutes in the above solution. There was an apparent bright tin coating on the steel and aluminum and a dark conversion coating on the magnesium.

Galvanic corrosion of the trimental assembly was first noticed after 2 hours exposure to salt spray. The pH of the above solution decreased from 6.7 to 5.8 during the coating formation. It was found that by increasing the pyrophosphate concentration, the adjusted pH could be maintained. The composition of the modified solution was as follows:

40 grams sodium stannate $Na_2SnO_3.3H_2O$

100 grams sodium pyrophosphate $Na_4P_2O_7.10H_2O$

10 grams dextrine

1 gram gelatin

Enough water to make a one liter solution

The pH of the above solution was adjusted to 6.8 with phosphoric acid (85%). The solution was heated to 195 ± 5°F. A composite specimen was immersed in the solution for thirty minutes. After processing there was an apparent bright tin coating on the three metals in the assembly. The same results were obtained with a second trimetal assembly. After processing 50 square inches of metal in a one liter of solution it was noted that the pH had not changed from the initial value.

Other Tin Solutions:

Solutions containing other tin compounds were prepared and studied for deposition of coatings on the trimetal assemblies.

The first solution contained a stannous fluoroborate solution. Approximately 65 ml of 57% stannous fluoroborate solution was added to a liter of water. The pH of the solution was adjusted and maintained between 5 and 7 by the addition of 5N sodium hydroxide solution. Composite specimens were immersed in the solution for twenty minutes. No satisfactory coatings were obtained on any of the metals in the trimetal assemblies. The magnesium was attacked by the solution. There was a thin, dark coating on the steel and no coating on the aluminum.

Solutions were prepared in which stannous oxide or stannic oxide and concentrated sulfuric acid were the active chemicals. No satisfactory coatings were deposited on the composite specimens. The coatings were either very thin or nonadherent.

Solutions were prepared from the resultant mixture of sulfuric acid (1-1) and metallic tin powder. 15 ml. of (1-1) sulfuric acid were added to ten grams of tin powder. The resultant mixture was stirred occasionally. The resulting mixture was diluted to a one liter solution. The solution was adjusted to a pH of approximately 7 with a 5N sodium hydroxide solution. The solution was heated to 195 ± 5°F. Trimetal assemblies were processed for thirty minutes. The coating was nonadherent on the aluminum in the trimetal assembly.

DISCUSSION

It was previously noted that when the pH of the stannous pyrophosphate solution was varied between 5 and 9, a different coating was produced on the trimetal specimens. Apparently the best coatings were obtained when the pH of the stannous pyrophosphate solution was between 7 and 8.2.

An investigation was initiated in order to determine if there was an optimum pH within the range of 7 to 8.2 in the stannous pyrophosphate solution. No optimum pH was found. The resultant coatings appeared the same throughout the range. The pH of the adjusted stannous pyrophosphate solution remained rather constant without further additions.

The concentration of the stannous pyrophosphate solution was varied in order to ascertain the best operating concentration. The best operating concentration appears to be the current formulation.

The stannous pyrophosphate solution satisfactorily coated the 5052 alloy of aluminum, when part of a composite specimen. An investigation was initiated in order to determine if the solution would coat other alloys of aluminum when part of a trimetal assembly. The solution satisfactorily coated the 1100 alloy of aluminum. The solution would not satisfactorily coat the 6061 aluminum alloy nor the 7075 aluminum alloy until they were alkaline cleaned in a carbonate-phosphate solution.

The coated specimen processed in the stannous pyrophosphate appeared to exhibit good galvanic corrosion resistance. The coating on 2024 aluminum alloy and the 7075 aluminum alloy exhibited poor adhesion after the salt spray corrosion resistance test.

The area of the aluminum panel in a trimetal assembly, and also the area of the magnesium panels in another trimetal assembly, was varied in order to determine if the size ratio of the two metals would affect the coating process. The size ratio of the two metals appeared to have very little affect on the coating of the metals in a trimetal assembly.

The stannate-pyrophosphate solution was investigated for coating trimetal assemblies. It was found that the stannate-pyrophosphate solution would coat all three of the metals in a trimetal assembly. The coatings were thin, yet they decreased the galvanic corrosion of the assembly. The galvanic corrosion of the coated trimetal assembly was first noticed after 2 hours exposure to salt spray. The pH of the modified solution, containing 100 grams of sodium pyrophosphate, remained rather constant during and after the coating of a number of composite specimens.

The other tin solutions prepared, and utilized as coating solutions, would not satisfactorily coat the three metals in the trimetal assemblies.

LITERATURE REFERENCES

1. Doss, Jodie, "Multimetal Coating Process for Composite Steel, Magnesium and Aluminum Structures," Rock Island Arsenal Laboratory Report No. 63-1651, 16 May 1963.

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